OpenMP assignment due next Thursday
- account problems on buzz? email or talk to staff@cs
- probably not a good idea to compile for profiling (with --pg) and for OpenMP at same time
  - can use omp_get_wtime() to time parts of your OpenMP() code – OK to call from different threads
- other questions?

Sample topics for group project posted by next week

Shared Memory Multiprocessors

- Cache coherence
  - to keep different copies of same memory location (data block) the same
  - caching causes the problem, but is needed for performance
- Snooping vs. directory-based coherence
  - shared medium (bus or switched network) vs. distributed directory to keep track of shared data blocks
  - either way, all memory accesses are to local copies near a processor, and data blocks change state and move around to where they are needed
  - state of each block kept track of with a finite state machine (shared, exclusive, read-only, etc.)

SGI Origin 2000

- Scalable distributed shared memory (DSM) machine
  - from small building blocks, so scale up and down
- Each node is a dual-processor machine, with access to local memory, interconnection network and I/O system
- Nodes connected via “bristled” fat hypercube network
- Cache coherence maintained via directory that keeps track of each data block (page)
  - both the state of the cache block, and where copies are located
  - protocol appears complicated, but all implemented in hardware, so usually fast – big problem is transitioning to exclusive state for writes, to invalidate copies and TLB entries
  - supports migrating whole pages across nodes, with OS help
- Memory system includes support for fetch-and-op primitives, to speed up some synchronization operations
  - avoid cache coherence activity
**SGI Altix**

- UV is current generation, after Origins
- Scales to 256 nodes (2 sockets/node, up to 8 cores/socket), 2K cores, 16TB memory in 1 global shared memory (GSM), in 1 Linux instance
  - limited by physical (44 bit) and virtual (48 bit) address spaces
  - sockets connected via fat tree
- Scales to 64 256-socket instances and 8PB memory, connected via NUMAlink through HUB chips in 8x8 torus
  - globally addressable memory (GAM) across the 64 Linux instances - think PGAS, or put/get, also good for MPI
  - 53 bit physical memory, 60 bit virtual
- System provides fast MPI implementation, fast collective operations, high performance I/O, reliability via error checking and retry, and offloading remote memory accesses to HUB

**Altix HUB chip (cont.)**

- Provides directory-based cache coherency for GSM and put/get for GAM
- Connects directly to QPI memory interface on Intel Xeon CPUs, not though PCI I/O bus
- Global Register Unit (GRU) for global addressing, TLB for address translation across nodes (directories), fast memory initialization w/o CPU aid, fast block copies (good for message passing too), scatter/gather memory ops
- Active Memory Unit (AMU) – cache coherent atomic memory operations, update multicasting for fast collective operations, message queues in cache coherent memory